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Original Article

Magnetic Resonance Imaging Compared With Rectal Endoscopic Sonography for the Prediction of Infiltration Depth in Colorectal Endometriosis

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The authors declare that they have no conflict of interest.

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Precis

Accuracies of magnetic resonance imaging and rectal endoscopic sonography for the infiltration depth of colorectal endometriosis were compared on 40 patients who underwent laparoscopic colorectal resection.

Abstract

Study Objective: To compare the accuracies of magnetic resonance imaging (MRI) and rectal endoscopic sonography (RES) in the prediction of the infiltration depth of colorectal endometriosis.

Design: Retrospective cohort study (Canadian Task Force classification II-2).

Setting: University teaching hospital.

Patients: Forty patients with symptomatic deep infiltrating endometriosis (DIE) of the rectum who underwent colorectal resection were included.

Interventions: All patients underwent an abdominopelvic MRI and RES preoperatively to assess infiltration depth of colorectal endometriosis, and segmental resection of the rectosigmoid by laparoscopy was performed if RES showed bowel invasion. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive and negative likelihood ratios (LRs), and intermethod agreement were calculated for DIE muscularis and submucosal/mucosal infiltration, confirmed by histopathological analysis.

Measurements and Main Results: For the MRI detection of DIE muscularis infiltration, the sensitivity, specificity, PPV, NPV, and negative LR were 68%, 100%, 100%, 20%, and 0.32, respectively. For the MRI detection of DIE submucosal/mucosal involvement, the sensitivity, specificity, PPV, NPV, and positive and negative LRs were 47%, 81%, 69%, 63%, 2.49 and 0.65, respectively. The PPV of RES detection of DIE muscularis infiltration was 93%. For the RES detection of DIE submucosal/mucosal layers, the sensitivity, specificity, PPV, NPV, and positive and negative LRs were 79%, 48%, 58%, 71%, 1.51 and 0.44, respectively.

Conclusion: In the current study, MRI is valuable for detecting endometriosis of the rectum but is less accurate in detecting submucosal/mucosal involvement than RES. Magnetic resonance imaging was not successful for preoperative determination of segmental resection versus a more conservative approach. When bowel involvement is detected by MRI, RES is not essential. When symptoms suggest DIE in patients without intestinal lesions detected by MRI, RES is necessary to exclude bowel invasion.

Keywords: Deep infiltrating endometriosis; Imaging modality; Laparoscopic colorectal resection

Introduction

Intestinal endometriosis concerns 5% to 12% of patients with endometriosis [1] and is defined as endometriosis involving the bowel only if the muscularis layer is invaded. In such patients, dyschezia, rectal bleeding, cyclic defecation pain, constipation and/or diarrhea are typical [2].

In patients with intestinal endometriosis, segmental rectal resection with colorectal anastomosis reduces recurrence and improves digestive and gynecological symptoms and quality of life [3]. However, it is associated with complications such as rectovaginal fistulae (1.8%–2.7%), anastomotic leakages (1.5%–1.9%) and pelvic abscesses (0.34%–1%) [4,5]. Alternatively, rectal shaving results in less morbidity while preserving organs, nerves, and vascular blood supply [6,7].

Transvaginal sonography (TVS), rectal endoscopic sonography (RES) and magnetic resonance imaging (MRI) are used to detect and localize intestinal endometriosis [8,9]. Transvaginal sonography is the first-line imaging modality for endometriosis assessment, whereas MRI and RES are second-line for the detection of upper digestive lesions and depth of colorectal lesions, respectively [9,10].

Although RES is a beneficial diagnostic tool for colorectal endometriosis, it has been suggested that MRI is the best noninvasive method for evaluating locations of pelvic endometriosis [11].

However, few studies have evaluated the accuracy of imaging to predict the infiltration depth of colorectal endometriosis [10,12,13,14,15]. In the present study, we aimed to compare the accuracies of MRI and RES in predicting the depth of colorectal endometriosis. This information could be useful to identify patients who do not require radical segmental rectal resection but rectal shaving only or a transmural local excision with primary closure.

Methods

This retrospective, single-center study was conducted between 2012 and 2015 and included 40 consecutive patients who underwent colorectal resection for DIE. All patients with symptoms of deep infiltrating endometriosis (DIE; dysmenorrhea, dyspareunia, chronic pelvic pain, dysuria) and colorectal endometriosis (dyschezia, cyclical rectal bleeding) underwent a physical examination and a preoperative abdominopelvic MRI and RES.

Histological examination was used as validation of bowel endometriosis and infiltration depth. Only patients with DIE muscularis involvement noted on preoperative RES underwent a segmental resection of the rectosigmoid, performed by laparoscopy. The study was approved by the local Institutional Review Board, and all patients were informed that their deidentified data would be collected for research purposes.

RES protocol

Rectal endoscopy sonography was performed by a single examiner (L.P.) with extensive experience in RES for DIE for all patients with symptoms possibly related to digestive rectosigmoid endometriosis.

The sonographer was blinded to the results of MRI.

The echo-endoscope used was a flexible Olympus Radial Electronic (Olympus, Rungis, France) with a 14.5-mm-diameter end, allowing 360° cuts on a perpendicular plane and oblique anterior echo-endoscopic visibility [12]. The device was coupled to an Aloka Alpha10 console (Aloka, Saint-Priest, France). The standard probe frequency used to detect nodules was 6 MHz, and 10 MHz was used when refining of an interpretation was needed (for example, to visualize the mucosa or submucosa). A Normacol® (Norgine, Rueil Malmaison, France) (sodium dihydrogen phosphate) enema was carried out two hours before the examination to reduce gas and fecal material-related artifacts. Ultrasonography was performed without sedation. However, in the event

of significant patient anxiety or foreseeable difficulties performing the test, sedation with propofol was available for fasting patients [12].

Normal anatomy appears as follows on ultrasound for rectosigmoid [12]. The interface between the serosa and muscular layer appears as an external hyperechoic line (thinner than 0.5 mm); hypoechoic external and internal smooth muscle layers (2 mm) are separated by a hyperechoic line; and hyperechoic mucosal and submucosal layers are separated by hypoechoic muscularis mucosa. Digestive parietal invasion was defined by the presence of a hypoechogenic nodule colonizing the rectal or sigmoid wall associated with a thickening of the muscular layer. Mucosal or submucosal infiltrations were characterized by interruption of their hyperechogenic line [12] (Figs. 1 and 2).

MRI protocol

Magnetic resonance imaging was re-interpreted by a single radiologist blind to both RES and histological results. We aimed to find out if MRI was more accurate than RES or not when RES was positive.

Magnetic resonance imaging examination was performed with a 1.5-T MRI device with 2- to 5-mm thick sections and a 1- to 3-mm gap. Intrarectal or intravaginal gel-based preparation was used, although not in all subjects, and antispasmodic drugs (Glucagen, Novo Nordisk, Paris, France) were occasionally injected to reduce peristalsis.

The MRI protocol included a series of at least three spatial imaging planes with acquisitions including T2-weighted and T1-weighted images with and without fat suppression. Gadolinium injection was not administered for every scan (Figs. 3 and 4).

The main aspects of the MRIs of endometriosis were described as hyperintense foci corresponding to hemorrhagic signs on T1-weighted and fat-suppressed T1-weighted MRI; hyperintense cavities on T2-weighted MRI; hypointense signs with low

enhancement on T1-weighted and T2-weighted with retractable or spiculated signs and fibrosis with signal intensity close to pelvic muscle on T1- and T2-weighted MRI [16].

Endometriosis lesions of the anterior wall of the rectosigmoid colon were observed as disappearance of the hypointense signal on T2-weighted images. The presence of nodules extending on the anterior and inferior wall of the rectosigmoid colon showing contrast enhancement on T1-weighted MRI were also observed. Muscular or mucosal and submucosal infiltrations were characterized by the extensive depth muscular thickening of the rectal wall (isosignal). All patients underwent laparoscopy with segmental resection of the rectosigmoid by the same surgical team using similar operative techniques. Antibiotic prophylaxis with cefazolin 2 g was administered, and a 10-mm laparoscope was used in the umbilical position with three other trocars. Segmental resection was guided by lesions in the digestive tract diagnosed by preoperative imaging and those that were macroscopically identified intraoperatively. A mini-laparotomy was performed to make the anastomosis using a circular mechanical clamp.

Histological examinations of the resected bowel were performed by the same experienced pathologist (F.W.) with extensive experience in recognizing DIE, who was blinded to the results of MRI and RES. Endometriosis was defined by the presence of fibrosis and muscular hyperplasia in association with ectopic endometrial tissue (i.e., glandular and stromal structures on light microscopy), as shown in Figs. 5 and 6.
The results of RES, MRI and pathological analysis of the excised tissues were compared. The maximum depth reached by endometriosis in the bowel was considered.

Statistical analysis

The sensitivity, specificity, PPV and NPV, test accuracy, positive and negative likelihood ratios (LRs) and corresponding 95% confidence interval (CI) of MRI and RES

were reported for each location of endometriosis and invasion depth (muscular layers and the colorectal submucosal/mucosal layers). Because only patients with muscular lesion on RES were included, it was not relevant to calculate sensitivity, specificity, NPV and LRs ratios for muscularis layer.

The intermethod agreement was calculated with Cohen's kappa coefficient. The degree of agreement was defined according to Landis and Koch [17] (< 0, no agreement; 0.00–0.20, slight agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, substantial agreement; and 0.81–1.00, excellent agreement).

The agreement between RES and MRI was calculated using three categories: no bowel wall invasion, muscularis, and submucosal/mucosal. The agreement between the radiological examination (RES or MRI) and histological results using the same categories was also calculated.

Results

Forty patients with a median age of 33 years were analyzed. The most common symptoms were dysmenorrhea (80%), dyschezia and chronic pelvic pain (both 70%) and dyspareunia (68%) (Table 1). All patients had a maximal interval of 4 months between imaging (MRI and RES) and surgery.

Histopathological examination showed that 18 (45%) of the 40 patients had muscular invasion only and 19 (48%) had associated submucosal or mucosal infiltration. In 3 patients, serosal involvement only was observed and no muscularis invasion (Tables 2 and 3).

MRI to predict depth of bowel invasion

Among the 40 patients, MRI suggested no bowel invasion (adherence only) in 15 cases and bowel invasion in 25 cases: 12 cases with muscularis involvement and 13 cases with muscularis and submucosal (± mucosal) involvement.

Among the 25 patients with muscularis invasion on MRI, all had at least muscularis involvement at histopathology. Concerning the 13 patients with submucosal involvement on MRI, 9 (69%) had submucosal involvement at histopathology (Table 2).

The sensitivity of MRI for the detection of muscularis layer invasion was 68% (95% CI, 62%–68%), and the specificity was 100% (95% CI, 32%–100%). The PPV and NPV were 100% and 20% respectively, and the negative LR was 0.32 (95% CI, 0.32%–1.17%) (Table 4).

For submucosal (± mucosal) layer invasion, the sensitivity of MRI was 47% (95% CI, 30%–61%), and the specificity was 81% (95% CI, 65%–93%). The PPV and NPV were 69% and 63%, respectively, and the positive and negative LRs were 2.49 (95% CI, 0.84%–8.57%) and 0.65 (95% CI, 0.42%–1.09%), respectively (Table 4).

When considering the prediction of infiltration depth according to three categories (no lesion, muscularis, and submucosal/mucosal layers), the number of observed agreements was 20 (50% of the observations).

RES to predict depth of bowel invasion

Rectal endoscopic sonography diagnosed 14 patients with muscularis involvement, 23 patients with muscularis and submucosal involvement, and 3 patients with muscularis, submucosal, and mucosal involvement.

Among the 14 patients with muscularis invasion identified by RES, 8 (57%) had muscularis involvement at histopathology, and 4 (29%) also had submucosal or mucosal involvement. Concerning the 26 patients with submucosal or mucosal impairment

identified by RES, 15 (58%) had submucosal or mucosal involvement at histopathology (Table 3).

Concerning the specificity of RES for the detection of muscularis layer invasion, three cases were overestimated, but in those cases, invasion was described as very superficial adhesion of muscularis at RES. Typically, patients with suspected serosal endometriosis do not undergo segmental resection and should undergo serosal resection only and not digestive tract resection. In the current study, owing to overestimation of bowel wall infiltration at the time of RES, these three patients underwent segmental resection when there was only serosal involvement or superficial invasion noted by pathology.

The sensitivity of RES for the detection of submucosal or mucosal invasion was 79% (95% CI, 61%–92%), and the specificity was 48% (95% CI, 31%–60%). The PPV and NPV were 58% and 71%, respectively, and the positive and negative LRs were 1.51 (95% CI, 0.88%–2.24%) and 0.44 (95% CI, 0.13%–1.26%), respectively (Table 4).

When considering the prediction of infiltration depth according to three categories (no lesion, muscularis, and submucosal/mucosal layers), the number of observed agreements was 23 (58% of the observations).

Combination of MRI and RES to predict depth of bowel invasion

When considering the prediction of infiltration depth according to the three categories (no lesion, muscularis, and submucosal/mucosal layers), the number of observed agreements between RES and MRI was 12 (30% of the observations), and the intermethod agreement was –0.02 (95% CI, –0.20%–0.15%).

Magnetic resonance imaging showed no bowel invasion (adherence only), whereas RES did in 15 patients (38%). On RES, one-third (5/15) had muscularis layer involvement, and 10 had submucosal-mucosal layer involvement (Fig. 7). In this group of

5 patients with “no bowel invasion at MRI/muscularis layer involvement at RES”, histological examination reported 1 patient with muscularis layer involvement, 2 patients with submucosal/mucosal involvement and 2 patients without lesions (Figs. 8A and 8B).

Concerning the 10 patients without bowel invasion on MRI and submucosal-mucosal invasion on RES, histological examination showed 5 patients with muscularis involvement, 4 patients with submucosal-mucosal involvement and 1 patient without lesions. Finally, among the 15 patients without bowel invasion at MRI but with bowel invasion on RES, in 12 patients, histological examination confirmed diagnosis of bowel invasion.

Discussion

In the present study, we investigated whether MRI and/or RES could correctly determine patients who would benefit from rectal shaving because the procedure does not invade the colorectal submucosa. The PPV for MRI was superior to that of RES (100% versus 93%) for muscularis as well as for the submucosal/mucosal invasion (69% versus 58%). Rectal endoscopic sonography showed higher sensitivity than MRI (79% versus 47%, respectively) for the detection of submucosal/mucosal infiltration. Based on the results of the present study, when MRI detects bowel involvement (either muscularis or submucosal/mucosal) RES is not required to confirm bowel infiltration. By contrast, when not detected by MRI, RES is necessary to exclude bowel infiltration, particularly in patients showing symptoms of bowel DIE.

From a surgical point of view, the aim of surgical treatment of DIE could be to resect the entire lesion, which is associated with lower recurrence and less morbidity. Meuleman et al [4] reviewed the clinical outcome of surgical treatment of DIE in 49 studies and reported a low rate of recurrences with higher complications in the group that underwent bowel resection anastomosis (5.8% versus 17.6%) than the mixed surgical group (full thickness resection and/or shaving).

Studies have shown that rectal shaving was responsible for endometriosis lesion persistence in 84% of cases [18] and discoid resection in 42% of cases [19] compared with 31% of patients who underwent colorectal segmental resection [20].

The current study has several limitations. It is a retrospective study, and the classic bias encountered with such methodologies must be acknowledged. However, the radiologist who re-interpreted all MRIs and the sonographer who performed the RES were both blinded to the results of histopathology as well as other imaging. Only one radiologist read all MRIs, and RES was performed by 1 sonographer.

Another limitation is that the number of patients in the present study was relatively small, but the cohort of patients was homogeneous, and patients were managed consecutively, allowing a more reliable comparison.

Only patients with muscular lesion at least on RES were included, so it was not relevant to calculate sensitivity, specificity, NPV and LRs ratios for muscularis layer.

The final limitation of the study was that suboptimal MRI protocol were used, in accordance with recent European Society of Urogenital Radiology guidelines [21]; no systematic bowel preparation or antiperistaltic drugs were used. Gadolinium contrast was not standard protocol. For some radiologists, injection of gadolinium can be necessary to increase accuracy when there is ambiguity about a rectal lesion. With gadolinium, a 3-dimensional acquisition is used, allowing better spatial resolution and high-contrast resolution.

Regarding the 3 patients without bowel invasion (only adhesion) at histological examination, negative histological results have been reported by several authors [22,23] with rarefaction of glandular and stromal structures; thus, these results should not refute the diagnosis of DIE.

Interestingly, in the present study, the majority of discordant cases between MRI and histological examination were related to underdiagnosis of the lesions (i.e., depth of

bowel invasion on histological analysis was deeper than suspected on MRI). Such cases can be related to insufficient digestive preparation, as shown in Fig. 8. This finding emphasizes the importance of digestive preparation by enema and rectal opacification to improve DIE infiltration depth assessment.

Our results regarding the capacity of RES to predict DIE colorectal infiltration depth are in accordance with previous studies [11,12,14,15]. Doniec et al [14] reported a sensitivity of 76% and 66% for the muscularis layer and the submucosal layer, respectively, with a disagreement rate of 25% in a series of 32 patients with colorectal endometriosis. Bazot et al [11] reported an agreement rate of 68% in a series of 54 cases of colorectal resection.

Rossi et al [12] reported an agreement rate of 61% in a series of 38 cases, and a rate of 56% was reported in the study from Roman et al (16 cases) [15].

In the past decade, MRI has been validated for the assessment of number of lesions, location, size, and subsequent surgical resection [24-28].

Only one other study analyzed the capacity of MRI to predict the invasion depth of endometriosis on bowel wall infiltration. Busard et al [13] reported sensitivity, specificity, PPV, and NPV of 100%, 75%, 96%, and 100%, respectively, for the detection of colorectal endometriosis lesions of the muscularis layer. Among the 22 patients with muscularis impairment on MRI, 11 (50%) had muscularis involvement only, and 9 (41%) had associated submucosal or mucosal involvement. Among the remaining 2 cases, 1 had serosal involvement, and the other had mucosal involvement [13].

Various methods have been studied to improve MRI accuracy, such as rectal or vaginal preparation, but without proven benefits [29,30]. Positive results were found with 3-dimensional MRI, 3Tesla MRI, and jelly methods [13,31,32]. Hottat et al [31] analyzed the contribution of 3T pelvic MRI in preoperative assessment and showed improved accuracy with a sensitivity and specificity of 96.3% and 100%, respectively, for the diagnosis of DIE. Manganaro et al [32] reported the accuracy of 3T MRI in the evaluation

of posterior cul de sac obliteration and showed a sensitivity and specificity of 93% and 75%, respectively. However, none of these new imaging modalities have been evaluated to predict depth of bowel invasion.

Conclusion

Magnetic resonance imaging is valuable for detecting colorectal DIE but is less accurate than RES in detecting submucosal/mucosal layer involvement, and therefore cannot be used to determine whether patients should undergo segmental resection compared with a more conservative approach. When MRI detects bowel involvement (either muscularis or submucosal/mucosal layers), RES is not essential; however, if no intestinal lesion is detected by MRI, RES is necessary to confirm diagnosis in symptomatic patients. Further large, prospective studies are necessary to determine whether MRI is sufficient for detecting infiltration depth of colorectal endometriosis and ultimately the type of surgical repair best suited for this patient population.

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Fig. 1 Rectal endoscopic sonography of the invasion of the muscularis layer by an endometriotic nodule of the rectosigmoid.

Fig. 2 Rectal endoscopic sonography of the invasion of the mucosa layer by an endometriotic nodule of the anterior rectum.

Fig. 3 Magnetic resonance imaging of the sagittal sequence T2-weighted, retractable nodule of the rectum extending on the submucosa with a T2 hypointense signal.

Fig. 4 Magnetic resonance imaging of the oblique coronal T2-weighted sequence. Arrow = rectal nodule; Double arrow = mucosa-extended rectal wall lesion.

Fig. 5 Submucosa (left side*), muscular (middle*), and subserosa (right side*) infiltration of deep infiltrating endometriosis of the rectum. Zoom x 6.

Fig. 6 Submucosa infiltration of deep infiltrating endometriosis of the rectum (*). Zoom x 50.

Fig. 7 Depth of endometriotic involvement in the rectosigmoid on rectal endoscopic sonography (RES) and magnetic resonance imaging (MRI) and on histopathology. *SM-M = submucosa-mucosa.

Fig. 8 (**A**) Magnetic resonance imaging of the sagittal sequence T2-weighted, stenosis of the rectosigmoid junction. (**B**) Sagittal sequence T1-weighted showing the nodular lesion of the rectosigmoid explained by the presence of stools with hyposignal filling the rectal ampulla. Small arrow = masked by the hypointense signal of the stools in the rectal ampulla.

Table 1 . Baseline patient characteristics

Characteristics	
Median age, years (range)	33 (25–45)
Dysmenorrhea, n (%)	32 (80)
Dyspareunia, n (%)	27 (68)
Dyschezia, n (%)	28 (70)
Dysuria, n (%)	11 (28)
Chronic pelvic pain, n (%)	28 (70)
Infertility, n (%)	19 (48)

Table 2. Depth of colorectal infiltration of endometriosis on magnetic resonance imaging (MRI) and histopathology

	Diagnosis on histopathology				
MRI diagnosis	No digestive infiltration, n	Muscularis, n	Muscularis + submucosa, n	Muscularis + submucosa + mucosa, n	Total, n
No digestive infiltration	3	6	6	0	15
Muscularis	0	8	3	1	12
Muscularis + submucosa	0	0	2	0	2
Muscularis + submucosa + mucosa	0	4	7	0	11
Total	3	18	18	1	40

Table 3. Depth of colorectal infiltration of endometriosis on rectal endoscopic sonography (RES) and histopathology

	Diagnosis on histopathology				
RES diagnosis	No digestive infiltration, n	Muscularis, n	Muscularis + submucosa, n	Muscularis + submucosa + mucosa, n	Total, n
Muscularis	2	8	4	0	14
Muscularis + submucosa	0	10	12	1	23
Muscularis + submucosa + mucosa	1	0	2	0	3
Total	3	18	18	1	40

Table 4. Magnetic resonance imaging (MRI) and rectal endoscopic sonography (RES) results

	MRI		RES	
	Muscularis	Submucosa/ mucosa	Muscularis	Submucosa/ mucosa
Sensitivity, %	68	47	–	79
Specificity, %	100	81	–	48
Positive predictive value, %	100	69	93	58
Negative predictive value, %	20	63	–	71
Positive likelihood ratio	–	2.49	–	1.51
Negative likelihood ratio	0.32	0.65	–	0.44

Table 5. Comparison of rectal endoscopic sonography studies

Study	Authors	N	Type of study	Objective	Results
1	Bazot et al 2007 [11]	81 (54 rectal DIE and 47 resections)	Cohort	RES and TVS for rectal DIE infiltration	Agreement 68%
2	Rossi et al 2014 [12]	38	Retrospective, single-center	RES for rectal DIE infiltration	Agreement 61%
3	Doniec et al 2003 [20]	85 (32 rectal DIE and 25 resections)	Cohort	RES for rectal DIE infiltration	- Disagreement 25% - Sensitivity • muscularis: 76% • submucosa: 66%
4	Roman et al 2008 [21]	16 (14 resections)	Retrospective single-center	RES for rectal DIE infiltration	Agreement 56%

RES = rectal endoscopic sonography; TVS = transvaginal sonography; DIE = deep infiltrating endometriosis.

Table 6. Comparison of magnetic resonance imaging studies

Study	Authors	N	Type of study	Objective	Results
1	Busard et al 2012 [13]	28	Retrospective, single-center	MRI for rectal DIE infiltration depth	- Sensitivity: 100% - Specificity: 75% - PPV: 96% - NPV: 100%
2	Hottat et al 2009 [27]	41	Prospective	3T MRI	- Sensitivity: 96.3% - Specificity: 100%
3	Manganaro et al 2012 [28]	46	Prospective	3T MRI	- Sensitivity: 93% - Specificity: 75%

MRI = magnetic resonance imaging; DIE = deep infiltrating endometriosis ; PPV = positive predictive value; NPV = negative predictive value.